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(54) Secondary electron multiplier

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(72) Inventor: Haruo Maeda
c/o Matsushita Electric Industrial Co., Ltd.
Tokyo Research Laboratory
1006 Oaza Kadoma, Kadoma-shi

(71) Applicant: Matsushita Electric Industrial Co., Ltd.
1006 Oaza Kadoma, Kadoma-shi

(74) Representative: Toshio Nakao, Patent Attorney

Brief Description of the Drawings

Fig. 1 is a side view of a conventional secondary electron multiplier; Fig. 2 is an explanatory diagram of the operation thereof; Fig. 3 is a side view of one embodiment of the secondary electron

multiplier of the present invention; and Fig. 4 is an explanatory diagram of the operation thereof.

Detailed Description of the Invention

The present invention relates to an improved continuous dynode secondary electron multiplier. Conventional continuous dynode secondary electron multipliers are referred to as channel-type secondary electron multipliers and comprise parallel flat plate or pipe-shaped high resistive secondary electron emissive surfaces.

First, the constitution and operation of a conventional channel-type secondary electron multiplier will be described. The symbol 1 in Fig. 1 denotes a channel substrate configured from, for example, a glass-ceramic insulated pipe or parallel flat plate of which the interior surface is coated with a high resistive secondary electron emissive material 2.

The symbol 3 denotes a direct-current power source connected to both ends of the secondary electron emissive material 2 for producing an electric field that accelerates emitted secondary electrons in the axial direction of the pipe or parallel flat plate 1. The symbol 4 denotes a collector for collecting the multiplied secondary electrons, a power source 5 for producing an electric field that guides the emitted electrons into the collector 4 being connected between the collector 4 and the output end of the secondary electron emissive material 2. Thereupon, when a primary electron 6 is caused to fall incident upon the input end-side thereof, the primary electron 6 collides with the secondary electron emissive surface on the interior surface of the pipe or parallel flat plate 1 resulting in the generation of

a secondary electron 7, and this secondary electron 7, while being accelerated by the axial direction electric field in a parabolic path, collides again with the secondary electron emissive surface resulting in the emission therefrom of another secondary electron whereupon, thereafter, with this collision and emission being repeated, secondary electrons 8 are multiplied in a cascading formation and collected in the collector 4.

Assuming that in this case the channel is configured from two opposing parallel flat plate secondary electron multiplier surfaces, the upper and lower plates are connected to each other at the two ends thereof and an acceleration voltage is imparted to generate a uniform electric field in the axial direction between the left and right ends. A multiplier axial direction acceleration electric field created by equipotential lines perpendicular to the plate surfaces as indicated by the dotted line 9 of Fig. 2 exists in the interval between the upper and lower plates and, as is shown, this electric field accelerates the secondary electron 7 generated by the primary incident electron 6 in a parabolic trajectory causing it to collide with the opposing surface which results in the emission therefrom of a subsequent secondary electron 71 in a parabolic trajectory which then collides again with the opposing surface resulting in the emission of a subsequent secondary electron 72, and so on. In this case, the equipotential surface that accelerates the secondary electrons is perpendicular to the direction in which the secondary electrons are multiplied, the secondary electrons describe a parabolic trajectory in the interval between the parallel plates as shown in Fig. 2, and the number of collisions on the

secondary electron emissive surface is proportional to the ratio of the length of the secondary electron emissive surface in the axial direction of the tube to the distance of the interval between the plates. Accordingly, in order to produce high gain, the value of this ratio must be increased, the equipotential surface must be uniformly perpendicularly aligned with the tube axis, or the axial length of the tube must be increased.

Different to a conventional tube configured from two parallel flat plate secondary electron multiplying surfaces as described above, the present invention comprises a single secondary electron multiplier surface configuration that affords increased gain. An embodiment of the present invention is hereinafter described. A substrate 1 of Fig. 3 configured from a glass or ceramic describes an undulating sawtooth shape as shown in the drawing in which a secondary electron emissive surface 211 provided on a surface on which a low resistive metal thin film 21 serves as a substrate (on the long inclined surfaces) and a high resistive material 22 (on the short inclined surfaces) are separately provided by deposition or some other method and, as a whole, are alternately connected in series. A power source 3 for producing an electric field that accelerates the generated secondary electrons connects to the two ends of the series of connections between the high resistive surfaces and secondary electron emissive surfaces. Here, a laterally incident primary electron 6 collides with a first secondary electron emissive surface resulting in the emission of a secondary electron 7, this collides with a subsequent stage secondary electron emissive surface resulting in the emission of subsequent stage

secondary electron 71, and the process of secondary electron multiplication in which the electrons collide with subsequent stage emissive surfaces resulting in the emission of secondary electrons 72, and then 73, and so on continues. The movement trajectory of an emitted secondary electron from one secondary electron emissive surface 211 to a subsequent stage secondary electron emissive surface is shown in the type diagram of Fig. 4. The symbol 211 denotes a thin layer of a secondary electron emissive material provided on a surface on which a low resistive metal thin film 21 serves as a substrate, for example, an MgO or Kcl or other high secondary electron emitting material, while the wavy line denotes a potential-dividing high resistive surface 22 for imparting the appropriate collision potential to each secondary electron emissive surface 211 stage and producing, in the vicinity of this surface, an electric field that guides the emitted secondary electrons properly to the subsequent stage secondary electron emissive surface. The substrates 21 of the secondary electron emissive surface 211 and the high resistive surfaces 22 are connected one after the other successively in series and, as shown in Fig. 4, when a voltage is imparted by the power source 3 to both ends of these series of high resistive connections, an equipotential surface of the shape shown by the broken line 9 in the drawing is produced in the vicinity of the surface of the secondary electron emissive surface. As shown in the drawing, under the electric-potential distribution or electric field conditions created by this equipotential surface 9, the secondary electron 7 emitted from the secondary electron emissive material 211 of the secondary electron emissive surface describes a

parabolic trajectory with respect to the incident primary electron 6 and collides with the subsequent stage secondary electron emissive surface resulting in the emission of a subsequent secondary electron 71 which, moving in a similar trajectory, impinges upon the subsequent stage secondary electron emissive surface. Secondary electron multiplication is sequentially performed in this way.

In the present invention, in which the interior surface of a single flat plate is formed in a waveform shape on which secondary electron emissive surfaces and potential-dividing high resistive surfaces are alternately arranged in series, the generated secondary electrons are successively guided to subsequent stage secondary electron emissive surfaces by the waveform surface shape and the electric potential distribution in the vicinity of the secondary electron emissive surfaces that form a potential-dividing electric potential in the potential-dividing high resistive surfaces and, as a result, the drawbacks of the parallel flat plate channel-type secondary electron multipliers as described above that include, in addition to the constant expansion of the trajectory of the secondary electrons because the electric potential distribution is perpendicular to the tube axis and the irregularity in gain that is produced if the acceleration electric potential distribution is not perpendicular or is not uniform, the need to increase the ratio of the length of the tube axis with respect to the plate interval dimension and the need for a high voltage, are obviated. In addition, the secondary electron emissive surfaces and potential-dividing high resistive surfaces are provided on the waveform surface of the present invention in opposing directions so that, using a vacuum deposition

method, the desired configuration can be easily obtained by the deposition of a metal and secondary electron emissive material from one direction and the deposition of a high resistive material from the other direction. Because of the electric field component in the direction perpendicular to the secondary electron emissive surfaces in the secondary electron multiplier of the configuration of the present invention, effective gain is able to be produced with tubes of shorter axial length and at lower acceleration voltages than that which has been hitherto possible with conventional parallel flat surface channel-type secondary electron multipliers.

(57) Scope of Claim

1. A channel-type secondary electron multiplier, characterized by comprising a support body having an interior surface of which the cross-section along the tube axis is sawtooth, wherein a low resistive thin film layer with a second electron emissive layer provided on the surface thereof is provided on the surface out of the interior surfaces that opposes the direction of incidence of an electron beam, and a high resistive thin film layer is provided on the other surface, these two-layered bodies connected alternately in series being connected to a direct-current power source.

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発明の数 1

(全 3 頁)

1

2

⑤二次電子増倍管

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⑫発 明 者 前田晴雄
門真市大字門真1006株式会社松下電器東京研究所内
⑪出 願 人 松下電器産業株式会社
門真市大字門真1006
⑭代 理 人 弁理士 中尾敏男

図面の簡単な説明

第1図は従来の二次電子増倍管の側面図、第2図はその動作説明図、第3図は本発明の一実施例における二次電子増倍管の側面図、第4図はその動作説明図である。

発明の詳細な説明

本発明は連続ダイノード二次電子増倍管の改良に関するものである。従来の連続ダイノード二次電子増倍管はチャンネル型二次電子増倍管と呼ばれ平行平板或いはパイプ状の高抵抗二次電子放出面を有するものである。

まず従来のチャンネル型の二次電子増倍管の構成と動作を説明する。第1図において1はガラスセラミック等の絶縁性パイプ又は平行平板からなるチャンネル基体でその内面に高抵抗の2次電子放出物質2が被着されている。

3は2次電子放出物質2の両端に接続された直流電源で、放出された2次電子を加速するための電界をパイプ又は平行平板1の軸方向に作るためのものである。4は増倍された2次電子を集めるためのコレクタでコレクタ4と2次電子放出物質2の出力端の間には放出された電子をコレクタ4に導くための電界を作る電源5が接続されている。ここで入力端側から一次電子6を入射せしめると一次電子6はパイプ又は平行平板1の内面の2次電子放出面に当つて2次電子7を発生しこの2次電子7が軸方向の電界によつて加速されて放物線軌跡を描きながらさらに2次電子放出面に当つてそこからさらに2字電子を放出し、以下これをくり返しなだれ式に増倍された2次電子8がコレクタ4に集められる。

この場合チャンネルを相対する平行平板の二次電子増倍面で構成するとすれば、その両端において上下板は互に結線されて、左右両端間に一様な軸方向電界が生じる如く加速電圧が加えられている。上下平行平板の間の間隙には第2図に点線9で示すような板面に垂直な等電位線によつて与えられる増倍管軸方向加速電界があつて一次入射電子6によつて発生した二次電子を加速し7に示すような抛物線状の軌道で対向面に当たり更にそこから次の二次電子を放出させ次の抛物軌道71さらには72を生ぜしめることになる。この場合二次電子を加速する等電位面は二次電子増倍方向に垂直で、平行平板間間隙での二次電子軌道は第2図の様な抛物線状となり、二次電子面への衝突回数は間隙距離に対する二次電子面の管軸方向の長さの比に比例する。従つて高利得を得るためには前記比の値を大きくとる必要があり又等電位面を軸に垂直に一様に揃え又軸長を長くしなければならない。

本発明は上記の様な従来の如き二枚の平行平板の二次電子増倍面からなるものと異なり一枚の二次電子増倍面よりなり、利得を増大せしめんとするものである。以下本発明の一実施例につき説明する。第3図においてガラスまたはセラミックよりなる基板1は片面には図のような鋸歯状の凹凸が設けられ、長い斜面には低抵抗金属薄層21を基体とする表面に設けられた二次電子放出面211が短い斜面には高抵抗材料22が別個に蒸着その他の方法で設けられて全体でそれ等が交互に直列に接続されている。この高抵抗面と二次電子放出面との一連の接続の両端には発生した二次電子を加速する電界を作るために電源3が接続さ

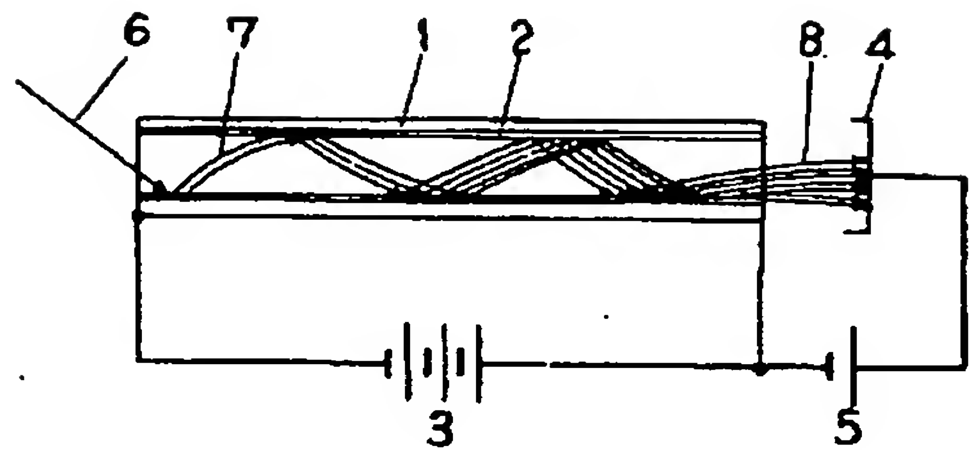
れている。いま一次電子6が左右から入射し第一の二次電子放出面に当たり二次電子7を放出し、これがまた次段の二次電子放出面に当つて次段の二次電子71を放出し、さらに次の段へ当つて72，73……と二次電子増倍が進められることになる。一つの二次電子放出面211から次段の二次電子放出面への放出二次電子の運動の軌道は第4図の模型に示す如くである。211は低抵抗金属薄層21を基体とする表面に設けられた二次電子放出材料、例えばMgO，Kcl其他の高二次電子放出材料の薄層を表わし、波線は各段の二次電子放出面211に適当な衝突電位を与えその面近傍に放出二次電子をたくみに次段二次電子放出面へ導くための電界を作るための分圧高抵抗面22である。二次電子放出面211の基体21と高抵抗面22は次々と順次直列に接続され、第4図の様に電源3によりこれ等一連の高抵抗接続の両端に電圧が加えられると二次電子放出面の面近傍には図の破線9の示す様な形の等電位面が作られる。この様な等電位面9のような電位分布もしくは電界の状況では図の示すように入射一次電子6に対して二次電子放出面の二次電子放出材料211から放出される二次電子7は拋物状の軌道をとつて次段の二次電子放出面に突当り次の二次電子71を放出し同様の軌道をもつて次々段の二次電子放出面に射突する。この様にして次々と二次電子増倍が行なわれる。

本発明は一枚の平板の内面を波型にしそれに二次電子放出面と分圧高抵抗面を交互にかつ直列に配置し波型の面形状と分圧高抵抗面での分圧電位の作る二次電子放出面近傍の電位分布により発生二次電子を次々と次段の二次電子放出面に導く様にしたものであり、これによつて前述の平行平板のチャンネル型二次電子増倍管のように加速電位分布が管軸に垂直で発生二次電子の軌道を常に管軸方向に伸ばし、又加速電位分布が垂直且一様でないと利得にむらが出る外、利得の増大には間隙寸法に対する管軸長の比を大きくとる必要があり、高電圧を必要とする等の欠点を改善するものである。また本発明のような波型の面に交互に二次電子放出面、分圧高抵抗面を設けるのは真空蒸着法により方向をかえて、一方から金属及び二次電子放出材料、他方から高抵抗材料を蒸着せしめれば容易に希望の構成のものが得られる。本発明の如き構造の二次電子増倍管では二次電子放出面へ垂直な方向に電界成分があるため、従来の平行平面チャンネル型の二次電子増倍管のものに比べて短かい管軸長、低い加速電圧で有効な利得が得られる。

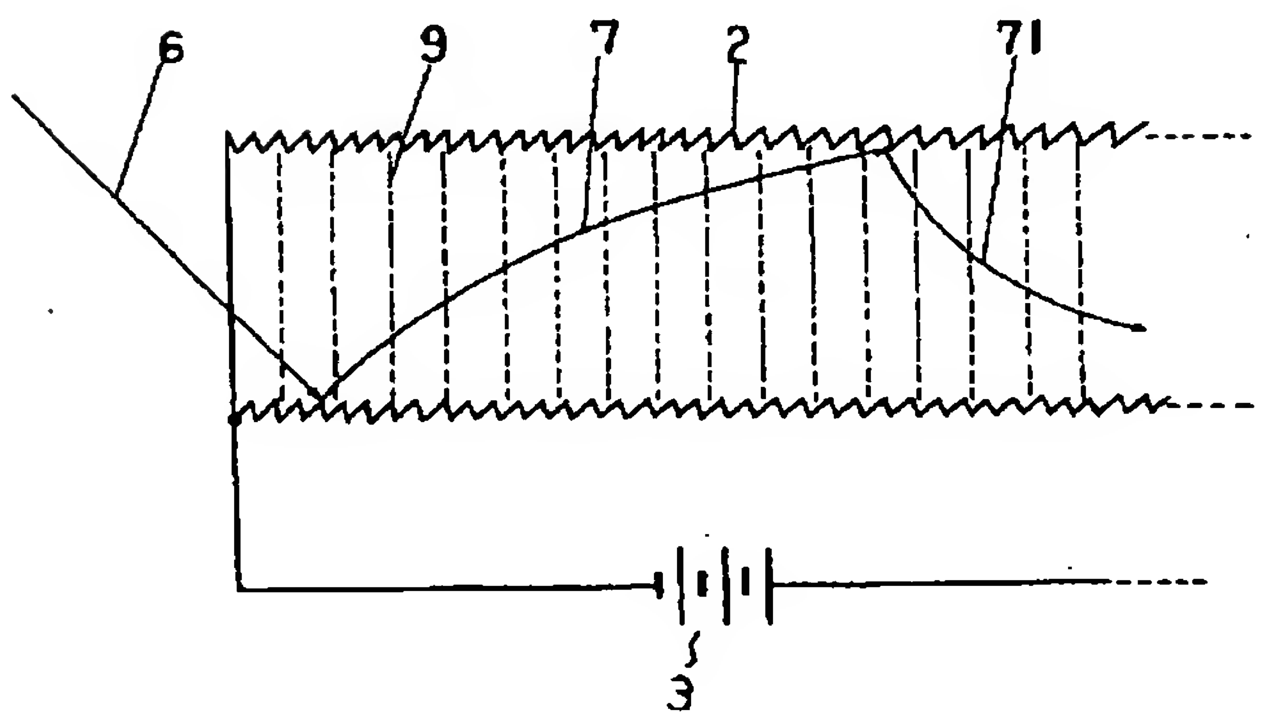
㊿特許請求の範囲

1　管軸に沿う断面が鋸歯状をなす内面形状をもつ支持体を備え、上記内面の内電子ビームの入射方向に対向する面に表面に二次電子放出層を設けた低抵抗薄膜層を設け、他の面には高抵抗薄膜層を設け、これらの2層の交互直列接続体を直流電源に接続したことを特徴とするチャンネル型二次電子増倍管。

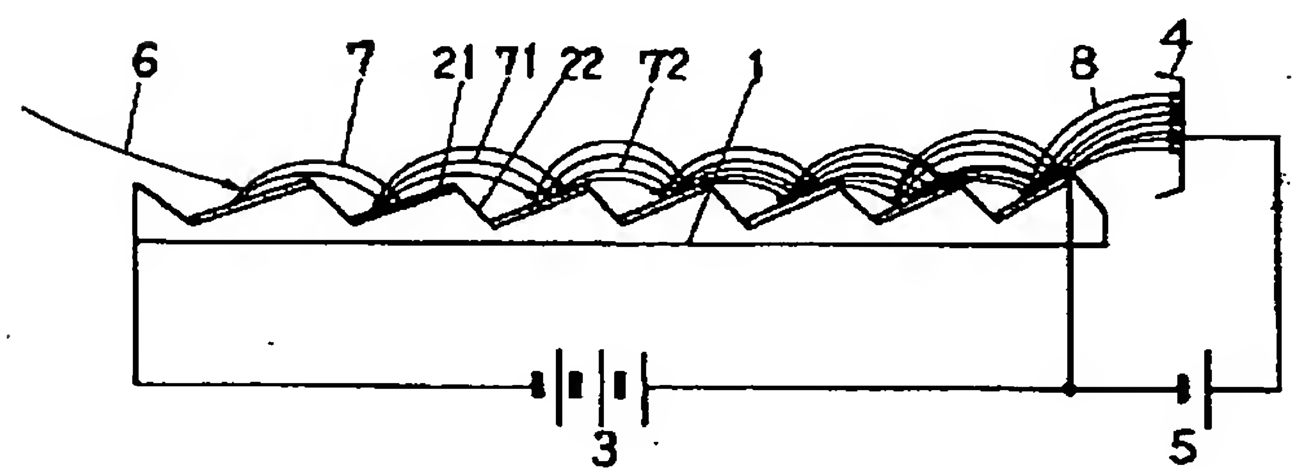
第1図



第2図



第3図



第4図